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ABSTRACT

This study extended concepts derived from Rothkopf's mathemagenic hypothesis to problem solving. While previous mathemagenic research has established that adjunct questions interspersed with written prose facilitates learning, it has been criticized as educationally nonsignificant because the research has focused on verbatim learning. To test basic mathemagenic concepts under educationally relevent conditions, a 2 x 2 ANOVA (analysis of variance) was used to assess the effects of type of adjunct questions (comprehension vs. verbatim) and placement of questions (before or after prose segments) on problem solving, with problem solving defined as the ability to apply concepts and principles to problem situations. College undergraduates read prose segments dealing with learning theory and answered related adjunct questions before completing five problem situations on the criterion test. Comprehension questions resulted in significantly higher problem solving scores, but no significant differences due to question placement were found. Subjects receiving comprehension postquestions did significantly better than all other groups. The results were consistent with previous mathemagenic hypothesis research findings. (Author/TS)

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# THE EFFECTS OF QUESTION TYPE AND QUESTION PLACEMENT ON PROBLEM SOLVING ABILITY FROM PROSE MATERIAL

## FINAL REPORT

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TABLE OF CONTENTS

## LIST OF TABLES

## SUMMARY

This study extended concepts derived from Rothkopf's mathemagenic hypothesis to problem solving. While previous mathemagenic research has established that adjunct questions interspersed within written prose facilitates learning, it has been criticized as educationally nonsignificant because the research has focused on verbatim learning. It has been suggested that adjunct questions and tests involving comprehension would be more appropriate for practical educational needs. To test basic mathemagenic concepts under more educationally relevant conditions, a 2 x 2 ANOVA was used to assess the effects of type of adjunct questions (comprehension vs. verbatim) and placement of questions (before or after prose segments) on problem solving, with problem solving defined as the ability to apply concepts and principles to problem situations. College undergraduates read prose segments dealing with learning theory and answered related adjunct questions before completing five problem situations on the criterion test. Comprehension questions resulted in significantly higher problem solving scores but no significant differences due to question placement were found. Ss receiving comprehension postquestions were significantly better than all other groups. The results were consistent with previous mathemagenic hypothesis research findings and demonstrated the potential usefulness to education of Anderson's distinctions between verbatim and comprehension questions.

# INTRODUCTION

The fundamental purpose of education is to impart the knowledge and skills necessary for functioning usefully in society. The means by which education produces this learning is through instruction. Since learning achievement ultimately is a function of instructional quality, it follows that a major concern of education is the identification of factors that comprise effective instruction and the incorporation of these factors in classroom instructional materials and procedures.

Education has traditionally drawn upon psychology to provide the scientific derivation of variables essential for understanding learning. The psychology of human learning in general, and especially of human verbal learning, are looked upon to uncover scientific principles directly related to learning and instructional processes. Verbal learning research is of particular interest in that the bulk of learning above lower elementary levels involves cognitive processes which are essentially verbal in nature.

The impact of verbal learning research on everyday instructional practices, however, has been slight. Classroom teachers at all levels--elementary, secondary, and collegiate--find very little from verbal learning research results that can assist them in any practical way to enhance their instructional performance and increase their students' learning attainment. The educational payoff from principles derived from this research, therefore, has been minimal, particularly when research output is related to what is still unknown about learning processes and the magnitude of current educational needs.

Several general factors contribute to this state of affairs. For one, the human is a complex organism whose penchant for individuality resists easy scientific classification and understanding. A second factor is that psychology is still a developing science using rudimentary tools and procedures to probe human behavior. A final factor is that education has not assimilated the bits of scientific knowledge there is into viable instructional practices.

Besides these general pervading factors about which little can be done, there are several more specific reasons which are amenable to change that also contribute to the meager influence of verbal learning research. The first lies in the nature and purpose of most verbal learning studies. Traditionally, these studies have emphasized the learning and retention of words, nonsense syllables, or sentences in an attempt to find general scientific principles and laws. Thus, paired associate, serial anticipation, and similar experimental paradigms have been widely used because they are congruent with the rigorous standards for control required in scientific investigation. Still, this research is far removed from the conditions likely to be found in actual instructional environments. As Carroll (1971) points out, useful analogies between list-learning and the type of learning that occurs in classrooms are difficult to draw.

A second specific reason for the minimal impact of verbal learning research on everyday practices is that emphasis is placed upon experimental procedures and methodology rather than on the generation of results that have direct implications for classrooms. The majority of studies are conducted by scientists interested in performing scientific research and the stress, therefore, is placed on designing sound experiments. Consequently, independent and dependent variables are selected for investigation on the basis of the extent to which they can be specified, quantified, and manipulated; far less concern is shown for the generalizability of results or the feasibility of variables studied for typical instructional environments.

A third reason contributing to the failure of verbal learning research to affect instructional practices significantly centers on the failure of most studies to incorporate into their research designs the basic rationales and principles of instructional technology. Evolving out of military, industrial, and educational efforts to develop training and instructional systems relevant to specific learning needs, instructional technology combines concepts and methods from systems analysis, behavioral psychology, and instructional media.

Numerous instructional technology models exist and vary somewhat in detail (e.g. Gropper & Short, 1969; Briggs, 1970; Drumheller, 1971), but they all emphasize a concern for the practical relevancy of instruction.

For example, they all recognize the need to analyze the learning task or content to establish learning priorities, to specify precise instructional objectives, and to delineate the relationship between testing requirements and learning objectives. It is these very practices that seldom are accommodated in verbal learning research.

Each of the three specific reasons mentioned above can be characterized as special cases of the more fundamental differences that distinguish basic science from applied science. On the one hand, most verbal learning research is basic science and those conducting it are interested in the discovery of basic laws and principles without regard to the immediate applicability of results. In contrast, those responsible for developing and/or presenting instruction function within the realm of applied science and they are concerned with immediate applicability of results. That very little from basic science is useful to applied science signifies the existence of a gulf between the two and suggests a change in approach is needed if science is ever to have a significant influence on education.

One recent approach that seems promising for narrowing the gulf between verbal learning research and practical instructional needs is prose learning research. A specialized branch of verbal learning, prose learning starts by acknowledging that by far the largest amount of instructional activity involves "telling things" to students by written or spoken word, whether in textbooks, lecture, or audio-visual media. The focus of prose learning research is on how to construct prose materials to facilitate learning. Significantly, this approach begins to overlap both basic and applied science.

Prose content and the variables relevant to learning from prose are subject to laboratory manipulation and control. Systematic experimentation, the methodology of basic science, can thus be brought to bear in the discovery of fundamental knowledge. At the same time, prose is meaningful verbal content typical of the kind encountered in education. Thus, by the very nature of the content investigated, any prose research findings will be more generalizable to existing learning populations and instructional environments than would findings resulting from the traditional "nonsense syllable" research. E. Z. Rothkopf's mathemagenic hypothesis is a particular approach

to prose learning research that has been regarded as especially promising in bridging the gap between our knowledge of learning and the processes of everyday instruction (Glaser & Resnick, 1972). The focus of the present study was on this research approach.

## Mathemagenic Hypothesis Research

Rothkopf's work has centered on the scientific study of those student activities on which learning from written prose material depends. Rothkopf (1965, 1969, 1970, 1971a) has coined the concept of mathemagenic behaviors to describe the activities that "give birth to learning" when confronted with written instruction. Since mathemagenic behaviors are hypothesized to determine the effective stimulation that results during reading, they directly affect what is learned.

Rothkopf (1970) has defined three different classes of mathemagenic activities. Classes I and II (Orientation and Object Acquisition) are readily observable and refer to such behaviors as being in physical proximity to instructional objects and being able to procure and utilize them. Class III mathemagenic behaviors are characterized as reading activities and include scanning, systematic eye fixations, translation into internal speech and/or symbols, and the mental accompaniments of reading such as discrimination, segmentation, and processing.

The major research interest generated by this theory has been to discover how to control the essentially unobservable Class III mathemagenic behaviors so that maximal effective learning results from reading prose. Test-like events (or adjunct questions) interspersed within written prose text have been found to be one such control. The assertion is that questions asked during the presentation of prose shape the learner's attention and processing--or what Rothkopf calls mathemagenic behavior.

Rothkopf (1966) experimentally investigated whether adjunct, test-like questions have facilitating effects on learning from written prose, and whether it matters if the questions precede instructional passages (prequestions) or follow them (postquestions). Specific facilitative effects

were obtained for both prequestions and postquestions (i.e. subjects were able to answer criterion test items covering the same information as asked by the experimental questions). Only postquestions had generally facilitative effects (i.e. subjects were able to answer criterion test items about information not covered by the experimental questions). A special control group (direct reference group) was instructed to read carefully but given no experimental questions. This group had significantly higher scores than did the regular control group. Both the direct reference group and the postquestion group had increased reading time, which was attributed to mathemagenic behaviors. Data supporting the facilitating effects of postquestions were also obtained by Rothkopf and Bisbicos (1967).

The remainder of the literature review is categorized by the major variables investigated in conjunction with the mathemagenic hypothesis.

## Position of Adjunct Questions Within Written Text

Frase (1967) varied passage length (10, 20, and 40 lines), question placement (before and after prose passages), and knowledge of results (given or not) to determine effects on criterion retention questions (questions which occurred during reading) and criterion incidental questions (not previously presented). There was a significant effect for all three factors. Postquestions facilitated incidental learning, 20-line passages were optimal for facilitating retention, and a significant interaction between knowledge of results and question placement indicated that question position does not make much difference if knowledge of results is provided. Additional data supporting the mathemagenic hypothesis were provided when Frase (1968a) found that postquestions significantly facilitated incidental retention, that retention increased with frequency of postquestions, and that test items relevant to questions were retained better than incidental material. Postquestions were attributed to be better because they seem to provide cues for the elicitation or shaping of efficient reading behaviors. Frase (1968c) further confirmed the superiority of postquestions over prequestions, of increased postquestion pacing, and of question-relevant retention over incidental. Peeck (1970) found that prequestions enhanced learning question-relevant information but not irrelevant information.

Natkin and Stahler (1969) also provided data supporting the mathemagenic hypothesis by finding that low experimental preexposure to questions have an arousal effect. Subjects (Ss) with no preexposure to questions increased retention from immediate to delayed testing while high preexposure Ss showed retention decline.

Morasky (1969) concluded that question placement was not a critical factor for short-term retention but that postquestions facilitated long-term retention. A replication of this study (Morasky & Willcox, 1970) revealed no significant learning differences between pre- and postquestion groups, but the prequestion group took significantly less time to read the materials. Extending the implications of this study, Morasky (1972) investigated the effects of adjunct question placement on eye movements. He reasoned that if mathemagenic behavior always increases as learning increases, and if eye movements or visual fixations are mathemagenic behaviors, then visual fixations should increase as learning increases. The results of this study showed that more visual fixations occurred for postquestions, but learning did not increase. This suggests that a simple increase in the quantity of some mathemagenic behaviors is not necessarily sufficient to influence learning.

## Type of Adjunct Questions

Frase (1968d) hypothesized that a general question, since it would have a large number of associates within the reading passage and require more information than a precise question, would enhance retention when presented before reading the passage. The results were opposite his predictions; that is, retention was lowest with general questions. While these results may have been a function of an experimental artifact (the paragraphs were only 36 words long), they suggest that questions can have subtle effects upon performance. Questions may cause Ss to pay close attention to the passage, but their phrasing might select out only a portion of the necessary stimuli. As already noted in another connection, Frase (1968a, 1968c) found that questions relevant to criterion test items resulted in superior retention over incidental questions.

Brunning (1968) varied the format of questions which followed prose passages. He compared statement-type (declarative sentences) and test-type (completion) review items. His data supported the mathemagenic hypothesis and indicated that test-type questions facilitated learning more than statement-type review items. Watts (1971) and Watts and Anderson (1971) compared multiple choice postquestions. The answers to the postquestions were either repeated examples from the passage or required the application of a principle described in the passage. The results indicated that application questions resulted in better posttest performance suggesting that Ss were forced to [illegible] more thorough processing of the passages.

Corrozi (1971) compared the effects of productive and reproductive questions on short- and long-term retention. The data indicated that productive questions result in superior long-term retention and that they improve performance for that type of question on both short- and long-term retention tests. McKenzie (1972) found that Ss who took eight weekly quizzes requiring the drawing of inferences were better able to draw new inferences on a final test than a group of Ss who took weekly quizzes requiring the recall of facts. Rickards (1973) studied the effects of meaningful learning and rote learning questions on recall of prose material. He concluded that meaningful learning questions which require the subsumption of facts under given ideas resulted in greater recall of relevant and incidental information than did questions requiring rote learning of facts or of ideas.

## Other Variables Studied in Conjunction With Adjunct Questions

Frase, Patrick, and Schumer (1970) explored the influence of three levels of motivation in modifying the effect of adjunct questions. They concluded that postquestions facilitated learning but that this tends to be reduced as motivation increases, suggesting that postquestions are important in maintaining learning behaviors at lower motivational levels.

Utilizing prequestions only, Frase (1971) manipulated type of adjunct question (inferential or factual) and incentive level. The results indicated that inferential prequestions with little direct instructive effects produced as high incidental factual recall as factual questions. This was

attributed to the inferential questions subsuming factual material thus insuring that Ss responded actively to the text information.

Rothkopf and Bloom (1970) investigated the effects of interpersonal interaction on the instructional value of adjunct questions. These researchers found that questions asked orally promoted more effective study of written material than written adjunct questions, and both question groups were significantly superior to a control group receiving no questions. This finding was replicated in a later study (Rothkopf, 1972) which found that the text relevancy of the question, and not just social interaction, was the facilitative ingredient of social contact. Berliner (1969) found that test-like events administered during a lecture increased learning more than note taking, while Sanders (1971) failed to find a difference between oral or written questions on retention tests.

## Synthesis and Assessment of Mathemagenic Research

In summarizing the research related to the mathemagenic hypothesis, Frase (1970) concluded that postquestions act as a confirmation for mathemagenic behaviors and maintain appropriate responses; that prequestions interact with text to permit selection of relevant information and rejection of incidental information; that continuity of question to text maintains effects of prequestions across a range of incentive conditions; and that informing the reader in advance about the structure of the text acts as a general orienting direction that controls learning behaviors pertaining to categories of information.

Rothkopf (1971b) reviewed conditions under which adjunct questions can affect learning from written prose material. These conditions are: when high ability Ss are in a low quality instructional environment; when questions are presented in a social context; when factual questions are derived from a single sentence in the text; when short answer questions are used; when response requirements for adjunct questions are directly related to the information required for criterion performance; and when the learner is unmotivated and cannot study well.

Carver (1970, 1972) reviewed the research on mathemagenic effects and critized it on the following grounds: (1) the failure to control the total "running time" for the learning; (2) the failure to control adequately Ss' strategies in dealing with texts and questions; (3) the failure to make research externally valid by making it more comparable to realistic learning situations; and (4) the failure to relate results to adequate theory.

Ladas (1973) reviewed five studies that reported results supporting the claim that factual review questions facilitate learning incidental information. (The studies reviewed were Brunning, 1968; Frase, 1967, 1968a; Rothkopf, 1966; Rothkopf & Bisbicos, 1967.) Due to methodological and statistical deficiencies in these studies, Ladas concluded that confidence can be placed in the results of only one of the studies. Ladas points out, however, that his critical review in no way invalidates experimental results dealing with direct instructive effects of questions on question-relevant material or other findings.

On the basis of existing studies, it is reasonable to support the notion that mathemagenic hypothesis research, by virtue of its emphasis on meaningful prose, its stress on the effects of test-like events, and its use of various grade levels of students as experimental subjects, begins to make verbal learning research more responsive to practical classroom needs. However, many of the relevant studies reveal certain methodological and conceptual deficiencies that still limit their generalizability and utility for operational instructional practices.

One shortcoming of most mathemagenic hypothesis studies is their almost complete reliance on verbatim recall as the measure of learning. The criterion tests administered after completing the prose reading typically requires subjects to recall or recognize as responses exact stimulus materials contained in the prose material. This verbatim learning is quite divorced from the more usual educational demand that students be able to apply concepts and principles contained in an instructional text to problem solving situations. As previously cited, Carver (1970) lists this deficiency as the failure to make research more externally valid to realistic learning situations.

A second and related shortcoming involves the types of adjunct questions commonly employed in mathemagenic research. Most of the inserted questions have entailed verbatim recall, an approach criticized by Watts and Anderson (1971) on the grounds that it is useful for only the most trivial of educational objectives. These researchers argue that for adjunct questions to be relevant for real educational practices, they should require comprehension in order to induce meaningful processing of text and thus improve performance on new criterion test questions also entailing comprehension.

In an incisive article, Anderson (1972) delineated useful distinctions between verbatim and comprehension questions. Verbatim questions consist of statements taken in literal word-by-word form from the instructional text. Whether the question concerns a concept or a principle (or rule), identifying the correct response requires only the ability to recognize words previously encountered in the prose text. Answering a verbatim question cannot be taken as evidence of comprehension, since it can be answered by matching its elements with surface orthographic or phonological features of the original text.

Comprehension questions, in contrast, are characterized by paraphrase in which the questions have no substantive words (nouns, verbs, modifiers) in common with the prose text statements but are equivalent in meaning. To answer a question based on paraphrase one has to have comprehended the original statement, since a paraphrase is related to prose text statements with respect to meaning but unrelated with respect to actual words (Anderson, 1972, p. 150).

Anderson (1972) further detailed a rationale for constructing questions that measure comprehension of either concepts or principles, the levels of learning in Gagné's (1970) schema that are prerequisites for problem solving and that typify the kinds of learning encountered in everyday instructional environments. For a question to test for comprehension of a concept, it can require one to identify either the appropriate paraphrase of the concept definition or to identify new instances of the concept and discriminate these from non-instances. For a question to test for comprehension of a principle, it can require one to select either the proper instance of the

consequent conditions when given an instance of antecedant conditions specified in a principle or to select the proper instance of the antecedant conditions when given an instance of consequent conditions specified in a principle. Anderson (1973) reported preliminary support for his basic notions that comprehension is required to learn principles that are expressed in language dissimilar from that of the original text.

Another frequent shortcoming of mathemagenic research (and one that is common to verbal learning studies in general) is the failure to specify why criterion test questions are chosen and the concomitant failure to delineate the relationship between criterion test questions and the purpose and nature of prose instruction. In reviewing how achievement tests (or criterion tests) used in experiments are constructed, Anderson (1972) found that two-thirds of the studies failed to present any rationale for asking criterion test questions and that only five percent indicated criterion test questions were constructed to correspond with instructional objectives. (This is an example of the point made earlier that the bulk of learning research fails to incorporate instructional technology principles which, in this instance, would prescribe developing criterion test questions on the basis of instructional objectives.)

To provide closure on Anderson's viewpoints in relation to the shortcomings of mathemagenic hypothesis research, it is his position that this research approach can be made more relevant to applied instruction by stressing comprehension rather than verbatim types of learning. This holds for both criterion tests from which measures of learning achievement are obtained and for the construction of adjunct questions. Moreover, criterion test questions should be selected on the basis of prespecified instructional objectives. These points were essentially incorporated in a study by Felker (1973) to determine the effects of adjunct postquestions on problem solving behavior. In this study the criterion test required problem solving in the sense that concepts and rules previously encountered in text had to be applied to unfamiliar cases, the adjunct postquestions were constructed to require comprehension and higher order processing (they did not, however, include all the formal characteristics suggested by Anderson), and the criterion test questions were based on prespecified instructional objectives.

The results of this experiment indicating that adjunct postquestions do facilitate problem solving behavior. This was consistent with other mathemagenic hypothesis research involving verbatim learning and, also, demonstrated that conditions likely to be found in instructional environments can be approximated and incorporated into experimental designs.

## The Research Problem

The purpose of the present study was to compare the effects of two different types of adjunct questions (verbatim and comprehension) and question position (prequestion and postquestion) on problem solving ability from written prose material. The following specific comparisons were made:

### The Effects of Adjunct Verbatim and Adjunct Comprehension Questions on Problem Solving

While there is ample evidence in the literature about the mathemagenic hypothesis in relation to verbatim recall and recognition, only one study (Felker, 1973) focused on problem solving, a learning activity more commensurate with everyday educational expectations. In addition, few studies have attempted to characterize and define type of adjunct questions along the rigorous distinctions suggested by Anderson (1972). In the present investigation, verbatim questions required rote memory or recognition of exact words from the text. Comprehension questions were paraphrases of text statements and required responses that implied understanding of the literal message contained in the prose and the ability to abstract and apply information to new situations.

### The Effects of Question Placement on Problem Solving

The research literature consists of numerous studies that demonstrated that adjunct prequestions and adjunct postquestions differentially affect verbatim learning. Some investigations (Rothkopf, 1966; Frase, 1967, 1968a) have found that postquestions have general facilitative effects on verbatim

learning while prequestions have specific facilitative effects. Because of the presumed differences in the fundamental processes underlying verbatim learning and problem solving, it could not be concluded from past research that these effects also hold for problem solving.

## METHOD

### Subjects

The subjects (Ss) were 95 introductory psychology students at the Greensburg Campus of the University of Pittsburgh.

### Materials

#### Prose Text

The prose instructional materials were drawn from six chapters of the book, Learning: Reinforcement Theory (Keller, 1969). These chapters covered the following basic psychology of learning topics: operant and respondent behavior, respondent conditioning, operant conditioning, extinction, and intermittent reinforcement. The material was divided into 15 separate prose segments typed on standard 8-1/2 x 11 inch sheets. To maximize the facilitative effects found by Frase (1967), each prose segment contained an average of approximately 20 lines of material. Each segment was either preceded or followed by an adjunct question which was typed on a separate sheet. The text's paragraph structure was not modified so the range of lines per sheet varied from 12 to 28.

#### Problem Solving Criterion Test

Following Gagné (1970), problem solving was defined as the ability to recall and appropriately apply information to an unfamiliar situation and the ability to detect incorrect sequencing or uses of information and rearrange it in proper order. The Problem Solving Criterion Test consisted of five problem situations requiring the application of principles (or rules) and concepts from the text. Each problem situation consisted of a number of specific applications that counted one point each. The possible score

for each problem situation varied with the highest possible total score being 29. The total score over all problem situations was the primary dependent variable measure. The particular information that was to be applied in the problem situations was derived on the basis of an analysis of the prose material and was specified in instructional objectives in accordance with Mager's (1962) recommendations. Problem Solving Criterion Test questions and related instructional objectives are presented in Appendix A.

## Comprehension Adjunct Questions

Using Anderson's (1972) rationale, at least two questions requiring comprehension of either concepts or principles were constructed for each segment of prose material. Each prose segment consisted of approximately 20 lines of text. One question from the several developed for each prose segment was selected to serve as an adjunct question in accordance with the following selection criteria:

- Questions directly related to instructional objectives were picked over questions related to subcompetencies;
- Questions testing principles (or rules) were picked over questions testing concepts;
- Questions requiring the identification of new instances of concepts were picked over questions requiring the selection of paraphrased definitions of concepts.

## Verbatim Adjunct Questions

Again, on the basis of Anderson's (1972) distinctions, at least two questions requiring verbatim recognition of exact wording were constructed for each segment of prose material. One question from the several developed for each prose segment was selected to serve as an adjunct question. This question was selected on the basis of its equivalence in content and focus to the comprehension adjunct question associated with the same prose segment.

## Comprehension Question Retention Test

Upon removal of the questions to be used as adjuncts, the 21 remaining questions were formed into a Comprehension Question Retention Test. This test was used for a secondary analysis to determine differences among the experimental groups on ability to answer multiple-choice questions testing comprehension of concepts and principles.

## Verbatim Question Retention Test

The 21 verbatim questions that remained after those serving as adjuncts were selected were formed into a Verbatim Question Retention Test. This test served a similar function as above except that the multiple-choice questions could be answered on the basis of verbatim recognition. Appendix B presents both the Comprehension and Verbatim Question Retention Tests.

## Procedure

During the second class meeting of the semester, the subjects were randomly assigned to one of the following groups:

- Comprehensive Prequestion Group (CPRE)
- Comprehensive Postquestion Group (CPOS)
- Verbatim Prequestion Group (VPRE)
- Verbatim Postquestion Group (VPOS)
- Control Group (CONT)

The experimenter distributed the test packets to the Ss. Each packet contained directions, the prose material, adjunct questions (except for the Control Group), and the Problem Solving Criterion Test. The experimenter read the directions to the Ss. No time limit was established since the 90-minute class period was sufficient and it was desired that each S work at his own best pace.

When Ss had completed reading the prose material during which they had answered the appropriate adjunct questions, they were administered the

Problem Solving Criterion Test followed by the Verbatim and Comprehension Question Retention Tests. Half of the Ss completed the Verbatim Question Retention Test first while the other half did the Comprehension Question Retention Test first.

## RESULTS

An initial one-way fixed effects analysis of variance was used to determine effects of the different treatments on the experimental groups on problem solving performance in relation to the Control Group. As shown in Table 1, a significant F value of 2.79 ($P < .05$; df 4, 90) was obtained indicating an overall difference among treatment groups on Problem Solving Criterion Test scores.

TABLE 1

Summary Table for One-Way Analysis of Variance for Performance on the Problem Solving Criterion Test by the Five Experimental Groups

| Source | SS | df | MS | F |
|---|---|---|---|---|
| Treatment (between groups) | 200.69 | 4 | 50.17 | 2.79* |
| Error (within groups) | 1619.26 | 90 | 17.99 | |

* $P < .05$

Duncan's New Multiple Range Test (Edwards, 1968) was applied to test for significant differences between each pair of group means. The results of this analysis are presented in Table 2. The mean score for the Comprehension Postquestion Group (CPOS) was significantly larger ($P < .05$) than the Control Group and all other treatment groups; comparisons between means for all other combinations were not significant.

TABLE 2

Summary Table for Duncan's Multiple Range Test
Comparing Mean Performance of the Five
Treatment Groups on the Problem Solving Criterion Test

| | | VPRE | CONT | VPOS | CPRE | CPOS | Shortest Significant Ranges |
|---|---|---|---|---|---|---|---|
| | Means | 13.10 | 13.42 | 13.53 | 13.79 | 17.05 | |
| VPRE | 13.10 | 0 | .32 | .43 | .69 | 3.95 | $R_2 = 2.74$ |
| CONT | 13.42 | | 0 | .11 | .37 | 3.63 | $R_3 = 2.87$ |
| VPOS | 13.53 | | | 0 | .26 | 3.52 | $R_4 = 2.97$ |
| CPRE | 13.79 | | | | 0 | 3.26 | $R_5 = 3.04$ |
| | | * VPRE | CONT | VPOS | CPRE | CPOS | |

*Treatments underscored by the same line are not significantly different at the .05 level. Those not underscored by the same line are significantly different at the .05 level.

A 2 x 2 factorial analysis of variance was calculated to determine the effects of question placement (pre- vs. postquestion) and question type (verbatim vs. comprehension) on problem solving behavior. Table 3 presents the treatment means and the respective row and column means on which this analysis was based.

TABLE 3

Mean Problem Solving Criterion Test Performance for Each Treatment Group and the Combined Groups

| Treatment | | Question Type | | |
|---|---|---|---|---|
| | | Verbatim | Comprehension | |
| Question Placement | Prequestion | 13.10 | 13.79 | 13.45 |
| | Postquestion | 13.53 | 17.05 | 15.29 |
| | | 13.32 | 15.42 | Total |

Table 4 summarizes the results of this statistical analysis. The data in both Tables 3 and 4 indicate a significant difference in effects due to question type. That is, comprehensive questions were significantly better than verbatim questions in facilitating performance on the Problem Solving Criterion Test. No significant differences due to question placement were found, although the obtained F value of 3.50 approached significance. The interaction effect was not significant.

TABLE 4

Summary of the 2 x 2 Analysis of Variance Using the Problem Solving Criterion Test Scores as the Dependent Variable

| Source | SS | df | MS | F |
|---|---|---|---|---|
| Question Placement (QP) | 64.47 | 1 | 64.47 | 3.50 |
| Question Type (QT) | 84.21 | 1 | 84.21 | 4.58* |
| Interaction (QP x QT) | 38.36 | 1 | 38.36 | 1.68 |
| Within | 1324.63 | 72 | 18.40 | |

*$p < .05$

Secondary analyses were conducted to determine the relationships among the Problem Solving Criterion Test and the Verbatim and Comprehension Question Retention Tests. The purpose of these analyses was to attempt to determine whether these three tests measured different learning processes as implied by Anderson (1972). The Pearson Product Moment Correlation coefficients were: .54 between Problem Solving and Comprehension; .41 between Problem Solving and Verbatim; and .54 between Comprehension and Verbatim.

Additional supplementary analyses were conducted to assess the differential effects of the treatments using Comprehension and Verbatim Question Retention Test scores as the dependent variables. A one-way analysis of variance on each dependent variable resulted in no significant differences ($F = .43$; df 4, 90 on the Comprehension Question Retention Test; $F = 1.42$; df 4, 90 on the Verbatim Question Retention Test). Table 5 summarizes the performance of the experimental groups on the Comprehension and Verbatim Question Retention Tests.

TABLE 5

Treatment Means and Standard Deviations of the Experimental Groups on the Comprehension and Verbatim Question Retention Tests

| Experimental Groups | Comprehension Question Retention Test | | Verbatim Question Retention Test | |
|---|---|---|---|---|
| | Mean | SD | Mean | SD |
| Comprehension Prequestion Group | 13.90 | 3.26 | 11.74 | 4.03 |
| Comprehension Postquestion Group | 13.95 | 3.31 | 12.68 | 3.80 |
| Verbatim Prequestion Group | 15.05 | 2.59 | 14.16 | 3.06 |
| Verbatim Postquestion Group | 14.42 | 4.02 | 14.20 | 3.43 |
| Control Group | 13.84 | 2.89 | 12.79 | 3.92 |

## DISCUSSION

The finding that question type, in this case comprehension questions, was more effective in increasing problem solving ability lends support to Anderson's (1972) basic distinctions concerning verbatim and comprehension questions. The interspersed comprehension questions required the ability to identify new instances of concepts or the ability to supply appropriate antecedant or consequent conditions to various scientific principles discussed in the prose text. A necessary requirement to answer comprehension questions was the ability to apply information to new situations, a condition which implies that "understanding" of the information must first have occurred.

The interspersed verbatim questions, in contrast, could be answered by recognizing exact instances from the text. Comprehension or "understanding" was not a prerequisite for answering the questions. Since the Problem Solving Criterion Test required the application and sequencing of various concepts and principles to formulate solutions to situations never encountered in the text, it is not surprising from Anderson's viewpoint that comprehension questions facilitated problem solving processes.

While no significant differences due to the placement of adjunct questions were found, this finding is tempered by the facts that the level of significance was approached, that postquestions resulted in higher mean performance than prequestions (see Table 3), and that the Comprehension Postquestion Group was the single most effective group in terms of problem solving (see Tables 1 and 2). These findings provide a reasonable basis of support for Rothkopf's mathemagenic hypothesis. Rothkopf's contention that adjunct questions interspersed within prose material enhances learning was confirmed in the present study with problem solving behavior, a result consistent with findings of previous studies stressing verbatim learning. The superior performance of the Comprehension Postquestion Group is also consistent with the facilitative effects found for postquestions in other studies (e.g., Frase, 1967, 1968a, 1968c; Rothkopf, 1966).

The present study provides evidence that suggests that Anderson's notions about the learning processes underlying comprehension adjunct questions may be useful in accounting for the mathemagenic effects on problem solving. The cognitive activity generated by comprehension questions would seem to be the dominant factor in eliciting the mathemagenic behaviors that affect problem solving. Since problem solving was defined as the ability to recall and appropriately apply rules to a problem situation and the ability to detect incorrect sequencing or uses of rules (Gagné, 1970), the information processing similarity between problem solving and comprehension question responses is evident. It is this similarity of cognitive activity that may account for the increased facilitative influence of mathemagenic behaviors on problem solving performance. It is not just the presence of adjunct questions that elicit mathemagenic behaviors important for problem solving, but type of adjunct question is also a significant factor.

Although comprehension questions had a significant effect on problem solving behavior, no such effect was found when either comprehension questions or verbatim questions were used as the retention measure (See Table 5). The fact that the problem solving measure was more susceptible to adjunct organizational treatments than either the verbatim or comprehension retention measures can possibly be explained by the nature of the response requirements. The Verbatim and Comprehension Question Retention Tests consisted of multiple-choice questions with four alternative answers (see Appendix B). The probability of correctly answering the questions could be increased through informed elimination of some alternatives by the test sophisticated Ss. Informed guessing effects may have masked any differential effects due to comprehension in that the verbatim question groups were able to select right alternatives without actually understanding the concept or principle involved. It was not until Ss had to formulate answers by applying concepts and principles on the Problem Solving Criterion Test that the facilitative effects of comprehension questions were revealed. This tends to imply that the nature of the response requirement of test questions may be an important factor in the degree to which a learner can demonstrate comprehension of information.

Although the organizational adjunct treatments had no effect on either the comprehension or verbatim retention measure and the mean scores for both measures were similar, the correlation coefficient between the two was relatively small (.54). This finding supports Anderson's contention that the two types of questions measure quite different types of learning. The correlation coefficient between problem solving and comprehension questions was .54 while the coefficient between problem solving and verbatim questions was .41. By the very nature of Anderson's distinction between verbatim and comprehension questions, the direction of the above coefficients was expected.

Although the external validity of the present study strictly extends only to undergraduates of a specific university, and no claim is made otherwise, several implications of potential practical value to education in general are suggested. One such is that test-like events interspersed within prose can enhance the learning of scientific concepts and principles and facilitate the ability to utilize them in the formulation of problem solutions. Another implication of the results is that adjunct questions that require comprehension of information in order to be answered correctly tend to increase problem solving capability. Still another implication is that carefully constructed adjunct questions may be used in conjunction with existing prose material and thereby facilitate learning and reduce the expense and time needed for specialized instructional development. A final implication suggested is that principles of instructional technology can be most helpful in classrooms by providing means to define precisely the focus of learning for students and to clarify the kinds of testing activity most appropriately suited to the learning requirement.

Several areas for future research have surfaced as the result of the present study. For example, the nature of the response requirement of adjunct comprehension questions may be an important variable in enhancing comprehension. If Ss constructed responses rather than selected them it might ensure that information is more actively processed and that more effective mathemagenic behaviors are elicited resulting, thereby, in better problem solving performance.

Another area of future research interest is the focus of adjunct questions. The question of concern here is whether there are differential effects on problem solving due to adjunct questions focusing on either

concepts or principles (or rules). This would also be of interest in testing some aspects of Gagné's (1970) heirarchical learning theory in that the relative importance of concepts and principles as prerequisites for problem solving could be studied.

A final suggestion for future research related to the present study would be to compare question type and placement on problem solving in other subject matter contexts. Comprehension postquestions were found superior in the present study with scientific content in which concepts and principles were logically related and the latter were built from the former. Whether or not the same facilitative effect would be found with subject matter involving, for example, principles of legal contracts or military personnel regulations remains to be demonstrated.

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# APPENDIX A

## Instructional Objectives, Criteria for Evaluating Performance, and Problem Solving Criterion Test Situations

*(Derived from Chapter 3 - Respondent Conditioning)*

## Instructional Objective and Criteria

Given a situation describing an improper approach to condition behavior by respondent conditioning, the learner will use the same materials and redesign the events to correspond to proper respondent conditioning principles by:

-listing the UCS (loud horn)
-listing the CS ("RECON")
-listing the UCR (startle)
-Pairing the CS and UCS in this order
-Pairing the CS and UCS at least several times
-Pairing the CS and UCS seconds apart
-Withdrawing the UCS and stating the response will occur with only the CS.

7 Points total (1 for each item above).

## Criterion Problem Situation

An instructor wanted to condition a pilot to be particularly attentive to the word "RECON" when it flashes on a control panel. Using a training simulator, the instructor first sounded a loud horn which caused the pilot to make a startle response. Then 30 seconds later he flashed the word "RECON". After repeating this sequence 3 times, the instructor then flashed the "RECON" signal, but the pilot did not make a startle response as expected.

Using the same materials as above, redesign the conditioning exercise so that it conforms to respondent conditioning principles.

*(Derived from Chapter 4 - Operant Conditioning)*

## Instructional Objective and Criteria

Given the requirement to condition some desirable behavior by instrumental conditioning, the learner will demonstrate his ability to use instrumental conditioning principles by:

- -listing the behavior to be reinforced (pick up clothes)
- -listing the reinforcing stimulus (e.g., candy, money)
- -presenting the S after occurrence of the behavior
- -presenting the S seconds after the behavior
- -presenting the S after the behavior several times.

The learner will be told to disregard any schedule of reinforcement for this problem situation.

5 Points total (1 for each item above)

## Criterion Problem Situation

The next door neighbor wants to teach her 5-year old son to pick up his clothes when removing them. Using instrumental (or operant) conditioning principles, briefly describe the behavior you would condition, and how you would do it. You need not include any schedule of reinforcement in your description.

*(Derived from Chapter 6 - Extinction)*

## Instructional Objective and Criteria

Given an undesired instrumental conditioned response, the learner will demonstrate the ability to properly apply extinction principles to unlearn the undesired response by:

-listing the behavior to be extinguished (the conditioned response - climbing on chair)

-listing the reinforcing stimulus (candy)

-withholding the reinforcing stimulus when the behavior is made

-stating it may take a long period of time to extinguish the response

-stating the response strength gradually fades (climbing response weakens).

5 Points total (1 for each item).

## Criterion Problem Situation

By using instrumental conditioning principles, you have conditioned your three-year old brother to climb on chairs by giving him candy. You now want him to unlearn this conditioned response. Briefly describe the behavior to be unlearned, how you would do it, and what the eventual results would be.

*(Derived from Chapter 6 - Extinction)*

## Instructional Objective and Criteria

Given a classical (or respondent) conditioned behavior, the learner will demonstrate his ability to properly apply extinction principles to unlearn the already conditioned response by:

- -listing the CS (red light)
- -listing the UCS (shock)
- -listing the CR (remove hand)
- -presenting the CS without the UCS
- -presenting the CS without the UCS several times
- -stating that the CS eventually will not elicit the CR.

6 Points total (1 for each item above).

## Criterion Problem Situation

You have conditioned a friend toremove his hand from a control stick whenever a red light comes on by shocking his hand several times a few seconds after the red light. You now want him to unlearn this response. That is, you do not want him to remove his hand automatically whenever the red light comes on. Briefly describe how you would make your friend unlearn this response.

*(Derived from Chapter 7 - Intermittent Reinforcement)*

## Instructional Objective and Criteria

Given the requirement to condition a behavior using a variable-ratio schedule of reinforcement, the learner will demonstrate his ability to apply variable-ratio reinforcement by:

- -listing the response to be conditioned (pecking)
- -listing the reinforcement (grain)
- -presenting the reinforcement after varying numbers of responses (e.g., after 5, then 7, then 3 responses)
- -presenting the reinforcement seconds after the response
- -presenting the reinforcement over a period of time
- -stating that the effect is regular rate of responding.

6 Points total (1 for each item above).

## Criterion Problem Situation

You want to teach a baby chick to make regular and persistent pecking responses on a red square. Use a variable-ratio reinforcement schedule, and a suitable reinforcer, and briefly describe how you would teach the pecking response.

# APPENDIX B

## Comprehension Question Retention Test

## and

## Verbatim Question Retention Test

C1. A response which automatically follows a specific stimulus and which requires no practice to perform is

A. An operant behavior.
B. A voluntary behavior.
C. A respondent behavior.
D. A general behavior.

C2. A variable ratio schedule is best demonstrated by

A. Giving a child candy each time he makes a desired response.
B. Giving a child candy after one minute, then two minutes, and then five minutes.
C. Giving a child candy after every five desired responses.
D. Giving a child candy after he makes one desired response, then after two desired responses, and then five desired responses.

C3. A fourth grade girl comes home and helps her mother prepare dinner. This represents

A. Respondent behavior.
B. Elicited behavior.
C. Operant behavior.
D. General behavior.

C4. A fixed-interval reinforcement schedule is best defined by

A. A rat reinforced with food after every five responses.
B. A rat reinforced with food after each response.
C. A rat reinforced with food every five minutes.
D. A rat reinforced with food at various intervals of time.

C5. A 30 year old woman, 18 year old boy, and 9 month old girl are in separate sound-proof laboratory rooms. When a loud "gun shot" noise is sounded in each room, you would expect

A. Only the 30 year old woman to make a startle response.
B. All three people to make a startle response.
C. No noticable response by any of the three.
D. Only the 9 month old girl to make a startle response.

C6. Resistence to extinction is best demonstrated by

A. A child "showing off" in school even though the class is not paying any attention.

B. A child "showing off" causing the class to laugh.

C. A child "showing off" causing the teacher to frown.

D. A child quits "showing off" when in class.

C7. Which of the following sequence of events best demonstrates the procedures leading to the development of a conditioned reflex?

A. When stimulus X (that causes no particular behavior) is associated several times with stimulus Y (that automatically causes a certain behavior) until eventually stimulus X alone will cause the automatic behavior.

B. When stimulus X (causes no particular behavior) is associated with stimulus Y (automatically causes a certain behavior) so many times that neither stimulus X nor stimulus Y will cause the automatic behavior.

C. When stimulus X (causes no particular behavior) is associated several times with stimulus Y (automatically causes a certain behavior) until eventually the automatic behavior is caused by stimulus Y alone.

D. When stimulus X (causes no particular behavior) is associated several times with stimulus Y (automatically causes a certain response) until eventually the automatic behavior is caused by many other stimuli besides X and Y.

C8. A rabbit has been conditioned to stand on its hind legs by giving it carrots whenever it does so. When the carrots are no longer given the rabbit will

A. Eventually stop standing on its hind legs.

B. Run around the cage.

C. Continue to stand on its hind legs.

D. Start biting the bars on the cage.

C9. While a mother walks her three year old son on a busy street, she would immediately yell "stop" each time the stop light turned red causing her son to stop and look up. If this were repeated several times respondent conditioning would occur and would be demonstrated by

A. The son always stopping when his mother yells "stop."

B. The son stopping when he sees a red stop light.

C. The son stopping only when he sees a red stop light and hears the word "stop."

D. The son stopping only when he sees any color of light.

C10. Extinction of a laboratory rat's bar-pressing behavior would be accomplished by

A. Removing the bar.

B. Withholding food when the bar is pressed.

C. Giving food just before the bar is pressed.

D. Changing the kind of food received when the bar is pressed.

C11. A boy playing soccer kicks the ball right after a loud car horn happens to sound. This is an example of

A. Emitted reflexive behavior.

B. Elicited involuntary behavior.

C. Elicited respondent behavior.

D. Emitted operant behavior.

C12. Pain (caused by a pin prick) and yellow light were paired together in a respondent conditioning experiment. The unconditioned stimulus is

A. Pain.

B. Yellow light.

C. Pain and yellow light combined.

D. Indeterminate from the above.

C13. Which of the following best describes the Law of Effect?

A. Patting a dog on the head after he "sits up."

B. Patting a dog on the head before he "sits up."

C. Patting a dog at regular intervals regardless of what he does.

D. Patting a dog on the head after sounding a loud horn.

C14. Respondent behavior is best exemplified by

A. A boy drawing a picture of a fire truck.

B. A boy hitting a baseball.

C. A boy reading his science lesson.

D. A boy immediately withdrawing his finger when he touches a hot stove.

C15. In a respondent conditioning situation a soft tone was followed by an air blast (causing automatic eyeblink) until eventually the soft tone alone would cause an eyeblink. To extinguish this conditioned reflex you would

A. Present the air blast alone.

B. Present the air blast first and then the tone.

C. Present the tone alone one time.

D. Present the tone alone over a period of time.

C16. Operant behavior is best defined as

A. Behavior that can be performed reflexively from the time of birth.

B. Behavior that creates some kind of change in one's environment.

C. Behavior that is based upon emotional reactions.

D. Behavior that cannot be observed.

C17. A psychologist claims that she has instrumentally conditioned a rat to spin a wheel in its cage by giving it sugar water each time it spun the wheel. The extent of this learning is best exemplified by

A. The rat spinning the wheel 100 times at one time period.

B. The rat spinning the wheel one time.

C. The rat spinning the wheel one time every hour for three hours.

D. The rat spinning the wheel one time each time the psychologist enters the lab.

C18. A chick, kitten, and six month old baby all blink their eyes when a puff of air is directed at their face. This indicates that

A. Air puffs always cause blinking.

B. There is no specific relationship between air puffs and blinking.

C. Air puffs would not cause a grown man to blink.

D. Air puffs only cause chicks, kittens, and six month old babies to blink.

C19. In an experimental laboratory a rat pushes a red button with his nose to get food whenever it is hungry. This behavior was learned because previous

A. Food was made available immediately after the rat first pushed the button with his nose.

B. Food was made available so that as soon as the rat ate it the button was pushed by the laboratory technician to release more food.

C. Food was made immediately available after the rat pushed the button with any part of its body.

D. Food was given immediately before the rat looked like it was going to push the button with its nose.

C20. A rat in an experimental laboratory "jumps" and displays other nervous behavior whenever a red light is flashed. This probably happens because

A. The red light was previously paired with an electric shock.

B. The red light was previously paired with music.

C. The red light is naturally threatening to rats.

D. The red light was previously paired with feeding.

C21. Which alternative sequence of events described below best captures the essence of respondent conditioning?

A. Flash bright light (causing eyeblink); seconds later sound chime; repeat several times; sound chime alone; eyeblink occurs.

B. Flash bright light (causing eyeblink); seconds later sound chime; sound chime alone; eyeblink occurs.

C. Sound chime; seconds later flash bright light (causing eyeblink); repeat several times; sound chime alone; eyeblink occurs.

D. Sound chime; five minutes later flash bright light (causing eyeblink); repeat several times; sound chime alone; eyeblink occurs.

V1. Respondent behavior takes in all those responses that are

A. Voluntarily performed.

B. Elicited by special stimulus changes.

C. Common to only humans.

D. Practiced to a high degree of competence.

V2. When a pigeon's reinforcements come in random, haphazard fashion, this is

A. Systematic schedules of reinforcement.

B. Fixed schedules of reinforcement.

C. Continuous schedules of reinforcement.

D. Variable schedules of reinforcement.

V3. When a bird gets food after it makes 20 pecks this is known as a

A. Static schedule.

B. Fixed ratio schedule.

C. Fixed interval schedule.

D. Conditioned schedule.

V4. Respondent behavior is

A. Emitted voluntarily.

B. Elicited automatically.

C. A characteristic of humans only.

D. Elicited only by visual stimuli.

V5. When, after long training, a pigeon during extinction makes 7500 responses this is known as

A. Resistance to extinction.

B. Submission to extinction.

C. Inextinguishable extinction.

D. Animal extinction.

V6. When a neutral stimulus is paired with an eliciting stimulus a few times, this previously neutral stimulus will come to

A. Decrease in strength gradually.

B. Evoke the same sort of response.

C. Cause a novel reaction.

D. Evoke many different responses.

V7. The same fundamental rules for respondent extinction hold for

A. Operant conditioning.

B. Respondent conditioning.

C. Operant extinction.

D. Reflex extinction.

V8. In respondent conditioning if a neutral stimulus follows the eliciting stimulus one can expect

A. No conditioning at all.

B. A good example of respondent conditioning.

C. A good example of operant conditioning.

D. Both respondent and operant conditioning.

V9. Extinction is

A. Strengthening behavior.

B. Providing reinforcement.

C. Conditioning behavior.

D. Withholding reinforcement.

V10. In Pavlov's experiment food was the _____ for the dog's salivation.

A. Conditioned stimulus.

B. Unconditioned stimulus.

C. Conditioned reflex.

D. Unconditioned response.

V11. The strength of instrumental conditioning is usually measured in terms of

A. Rate of response.

B. Length of response.

C. Type of response.

D. Time of response.

V12. If a little girl receives a pellet of chocolate after she pulls a handle down, one would expect her to

A. Pull the handle down again to get more chocolate.

B. Try some other kind of behavior to get chocolate.

C. Never pull the handle down again.

D. Run away from the handle.

V13. When one's eyes dilate in response to changes in the lighting of a room it is

A. A voluntary behavior.

B. An operant behavior.

C. A general behavior.

D. A respondent behavior.

V14. A conditioned reflex (established through respondent conditioning) may be broken down by

A. Presenting the conditioned stimulus and withholding the unconditioned stimulus.

B. Withholding the conditioned stimulus.

C. Presenting the unconditioned stimulus and withholding the conditioned stimulus.

D. Presenting the unconditioned stimulus.

V15. Those movements of an organism that have an effect upon or do something to his outside world are

A. Reflex behaviors.

B. Automatic behaviors.

C. Operant behaviors.

D. Respondent behaviors.

V16. What is strengthened by its consequences according to the Law of Effect?

A. A stimulus.

B. The result of an act.

C. An act.

D. A conditioned stimulus.

V17. Operant behaviors

A. Are elicited rather than emitted.

B. Are produced automatically.

C. Are common only to young children.

D. Are emitted rather than elicited.

V18. Respondent conditioning involves the pairing of a neutral stimulus and an eliciting stimulus. This conditioning requires

A. Hundreds of pairings.

B. A few pairings.

C. One pairing.

D. Pairings with other reflexes

V19. When a tone is paired with an electric shock, the tone represents the

A. Conditioned reflex.

B. Eliciting stimulus.

C. Natural reflex.

D. Neutral stimulus.

V20. Respondents are evoked by their own special stimuli

A. Only after considerable practice.

B. Above the age of six.

C. Right from the start.

D. Between the ages of one and six years.

V21. Operant behavior

A. Operates on this world.

B. Can be performed reflexively at the time of birth.

C. Is performed only during infancy.

D. Does not have to be learned.